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The primary purpose was to compare part-task training to whole-task training for a variety of dual-task combinations. Four experiments were performed. The first experiment examined the speed and accuracy of manual responses vs vocal responses when subjects performed a Stroop task. The second experiment was directly concerned with comparing the relative efficiency of part- versus whole-task training for multiple-task situations. The third experiment was designed to fill one of the more important gaps concerning combinations consisting of two tracking tasks. The fourth experiment examined the effect of response mode (manual vs vocal) on single- and dual-task performance as a function of task pacing. The first experiment provided some useful date while experiments 2 and 3 were inconclusive. Data from experiment 4 indicated that the use of voice recognition systems offers a number of advantages, particularly under dual-task conditions.

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EXAMINING THE RELATIVE EFFICIENCY OF PART- VERSUS WHOLE-TASK PRACTICE FOR MULTIPLE-TASK SITUATIONS

Final Technical Report
Contract No. DAAG29-84-K-0197

By

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EXAMINING THE RELATIVE EFFICIENCY OF PART- VERSUS WHOLE-TASK PRACTICE FOR MULTIPLE-TASK SITUATIONS

Introduction

As the title suggests, the primary purpose of this contract was to compare part-task training to whole-task training for a variety of dual-task combinations. At the time the proposal was written, there was no theory of part-task training nor was there much research comparing part- to whole-task training for multiple-task combinations. Constructing a theory of part-task training was beyond the scope of this effort. However, one of the goals of this research was to create a dual-task data base. Such a data base would increase that total amount of information available to investigators studying part- versus whole-task training and could be used in constructing a theory of part-task training.

Currently, there is one major theory of multiple-task information processing, Wickens' Multiple Resources Model (Wickens, 1980). Briefly, this theory proposes that human information processing capacity is composed of a number of specific resources. Although these resources have not yet been exhaustively identified, Wickens, Sandry, and Vidulich (1983) have argued that some resources are defined along four dichotomous dimensions: 1) stage of processing (perceptual/central versus response selection/execution), 2)

modality of input (auditory versus visual), 3) code of processing (verbal versus spatial), and 4) response mode (manual versus vocal). All four experiments performed under this contract used Wickens' Multiple Resources Model to construct task combinations and, when appropriate, to vary the characteristics of the combinations in a systematic fashion.

Experiment 1

The first experiment was performed by Dr. Grayson Cuqlock and Ms. Kathryn Bloem (Cuqlock and Bloem, 1986) at the Aberdeen Proving Ground. This experiment examined the speed and accuracy of manual responses versus vocal responses when subjects performed a Stroop task (Stroop, 1935). The stimuli for the Stroop task were English words printed in different colors. The subjects were required to process the meaning and the color of each word independently. Single-task performance was selected for study in this experiment because it requires a more basic type of information processing than that involved in dual-task performance. Thus, the P.I. and Dr. Cuqlock felt that this experiment might provide useful data for subsequent research. The effect of response mode on both the speed and accuracy of performance was examined because Wickens' model predicts that these two modes should affect performance differentially. Eight male and eight female subjects completed the experiment.

As predicted by Wickens' Model, the response mode did affect the reaction time but in a more complicated manner than anticipated; the response mode interacted with the stimulus dimension to be processed. Vocal responses to the color of a stimulus were longer than responses to its meaning. In contrast,

the average reaction time for manual responses to stimulus color were not significantly different from those to meaning. The authors concluded from these data that highly compatible processing-response mode combinations (word meanings with speech responses) are not affected by competing processing demands.

Experiment II

The second experiment (Damos, 1986) is directly concerned with comparing the relative efficiency of part- versus whole-task training for multiple-task situations. This experiment examined only tasks requiring discrete responses because few dual-task data are available comparing part- versus whole-task training for such tasks. Two combinations were constructed using Wickens' Multiple Resources Model. The two tasks composing the separate combination used different resource pools. That is, one task used visual stimuli, manual responses, and required spatial processing. The other task used auditory stimuli, vocal responses, and required verbal processing. The two tasks composing the shared combination required the same resources; both tasks used visual stimuli and manual responses. Both also required verbal processing.

One problem associated with part-task training concerns the amount of part(single)-task practice the subject should receive. Currently, there is no established relation between the amount of single-task practice received and subsequent dual-task performance. If the amount of single-task practice has little effect on subsequent dual-task performance, then whole-task practice may be more efficient than part-task. If the amount of

single-task practice is directly related to subsequent dual-task performance, part-task practice may be more efficient. Thus, the amount of single-task practice must be included as an experimental variable when comparing part- to whole-task training for any task combination.

Forty-eight female subjects completed this experiment. Each subject was assigned at random to one of six groups. Groups 1, 2, and 3 performed the shared resources combination; Groups 4, 5, and 6 performed the separate resources combination. Extensive pretest data were collected to establish the number of trials required to reach asymptotic performance on each of the four tasks. These data were used to determine the amount of training each experimental group received. Groups 1 and 4 received one trial on each task before performing the combination. Groups 2 and 5 received half of the trials required to reach asymptotic performance on each task before performing the combination; Groups 3 and 6 received all of the necessary single-task training on each task. Thus, Groups 1 and 4 were the whole-task groups; Groups 2, 3, 5, and 6 were part-task groups that received different amounts of single-task practice.

An analysis of the dual-task data revealed few significant between-group differences and none of these could be identified using post-hoc analyses. A detailed examination of the single-task data revealed the apparent source of the problem. Based on the pretest data, the P.I. assumed that, for any of the four tasks, single-task accuracy would improve while reaction time

decreased with increasing amounts of practice. Group 2, however, had faster reaction times and was more accurate than Group 3 on one of the tasks and had the same accuracy on the other even though Group 3 had twice as much practice on each of the tasks. Similarly, Group 5 was more accurate on one of the tasks than Group 6 despite the fact that Group 6 received twice as much practice. Thus, the single-task practice variable did not have the anticipated effect on performance, making any interpretation of the dual-task data problematic.

Experiment III

While Experiment II was in progress, Wightman and Lintern (1985) published a review of the part- versus whole-task literature for manual control tasks, noting several gaps in the data base. Experiment III (Damos, 1987) was designed to fill one of the more important gaps concerning combinations consisting of two tracking tasks. In addition this study, like Experiment II, examined the effect of the amount of single-task practice on dual-task performance.

Forty-eight female subjects completed the experiment. Each subject was assigned at random to one of four groups. Groups 1 and 4 received one single-task trial on each task before performing their combination; Group 2 received three single-task trials; and Group 3, six single-task trials. Groups 1, 2, and 3 performed 20 dual-task trials followed by one single-task trial on each task. Group 4, a control group, received 30 dual-task trials followed by one single-task trial on each task. One week after a subject completed the initial testing session, she returned for a retention session. During this session all subjects performed ten dual-task trials, which were preceded and followed by one single-task trial on each task.

An examination of the initial single-task training data revealed the same problem that occurred in Experiment II: The amount of single-task practice did not affect single-task performance in the anticipated manner. It was not possible, therefore, to compare the relative efficiency of part-task training to whole-task training as a function of the amount of single-task practice. Additionally, Group 2 was found to have significantly better tracking skills than any of the other three groups. These two problems did not allow any interpretation of the dual-task data.

Experiment IV

Because the results of both Experiment II and III were inconclusive, the P.I. and Dr. Cuqlock decided to change the emphasis of the fourth experiment. Experiment I demonstrated that the response mode of the Stroop task affected performance. Many other experiments have found comparable results under single- and dual-task conditions (see Wickens, 1980 for an example). There are, however, many unanswered questions concerning the effect of voice recognition systems on performance. Experiment IV (Damos, in preparation) examined the effect of response mode (manual versus vocal) on single- and dual-task performance as a function of task pacing.

The subjects performed two discrete tasks and their combination. Both tasks required verbal processing and one required short-term memory. Forty-eight male subjects completed the experiment. Each subject was assigned at random to one of four groups. Groups 1 and 2 responded to both tasks manually; Groups 3 and 4 responded manually to one task and vocally to the other. Both tasks and their combination were unpaced for Groups

1 and 3 and paced for Groups 2 and 4. All subjects practiced each task alone before performing their combination.

Not all of the data analyses have been completed at this time. Nevertheless, it appears that Groups 3 and 4 performed better under dual-task conditions than Groups 1 and 2 although there are no apparent between-group differences under single-task conditions. Thus, using a voice recognition system to respond to one of the tasks does seem to improve dual-task performance. The data from Groups 3 and 4 have also been examined on a response-by-response basis to determine how subjects react when the voice recognition system rejects their utterances. There is some reason to believe that subjects may become increasingly frustrated by system rejections, especially under paced conditions. This frustration may manifest itself in an increasing rejection rate or by changes in task priorities. The analyses that have been completed show little evidence of either of these phenomena.

Conclusions

The results of Experiments II and III add little to the part- versus whole-task data base. Both of these experiments, however, revealed serious problems associated with manipulating the amount of single-task practice. A review of the literature shows few studies examining the effect of the amount of single-task practice on subsequent dual-task performance. It may be, therefore, that other investigators have encountered similar problems but failed to report them.

It is important that research on part- versus whole-task training continue for both theoretical and practical reasons. The development of inexpensive microprocessors has led to the construction of part-task trainers for complex tasks, such as flying a helicopter. Because there is no theory of part-task training, there is no way to determine if these trainers are being used as effectively as possible. The article by Wightman and Lintern (1985) is the first step towards developing a theoretical framework for part- versus whole-task training, but it is concerned only with manual control tasks. More effort then needs to be devoted to developing a data base and a theory for discrete tasks.

Although the data from Experiment IV have not been completely analyzed, it is apparent that the use of voice recognition systems offers a number of advantages, particularly under dual-task conditions. Additionally, none of the postulated disadvantages of these systems, such as increasing rejection rates with increasing levels of subject frustration, have been found. Thus, the use of these systems under even higher levels of information processing load and time stress should be examined.

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